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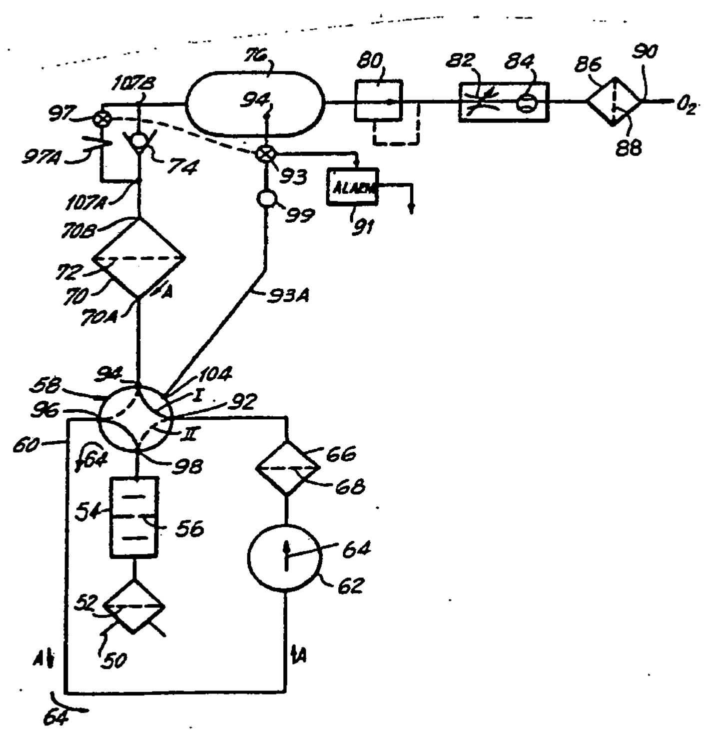
(54) Title: OXYGEN CONCENTRATOR

(57) Abstract

An oxygen concentration system which provides oxygen without the necessity of switching between two molecular sieve adsorbent tanks. An oxygen ballast tank (76) for storing and releasing stored oxygen is provided with a monitor (94) for monitoring the pressure within the tank and is fed by a single cycle sieve tank (70) containing a molecular adsorption material. A flow of atmospheric gas is directed through sieve tank (70) for removing nitrogen, and oxygen is directed from sieve tank (70) to ballast tank (76). The monitor (94) responds to a predetermined build up in pressure in ballast tank (76), cutting off the flow to the ballast tank (76) and reversing the flow in sieve tank (70) for a predetermined period of time for purging the sieve tank (70), by evacuation. A final shot of oxygen from ballast tank (76) to sieve tank (70) completes the purge.



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OXYGEN CONCENTRATOR

Technical Field

The present invention relates to oxygen concentration systems, and more particularly to a novel and improved oxygen concentration system employing fewer components than heretofore achievable.

Background Art

Prior art oxygen concentration systems have operated upon the principle of adsorption through a molecular sieve material for the purpose of scrubbing nitrogen molecules from the atmosphere, thereby allowing an oxygen concentrated atmosphere to pass therethrough. A typical difficulty with such systems is that the molecular sieve material in a molecular sieve tank of usable size will normally saturate within about 15 or 20 seconds of normal operation. It is therefore necessary to backwash the molecular sieve filter material for the purpose of removing the nitrogen molecules so as to allow the material to be refreshed for the next cycle. In order to prevent interruption of the operation, it is conventional to provide a second molecular sieve tank which will be operating normally while the first tank is being cleared. When it is time for the second tank to be cleared, the operations of the two tanks are reversed once again and the cycle continues. The alternative pressure and depressure cycles for filter renewing purposes is known as a pressure swing cycle. The difficulties encountered in providing valving, tubing, controls and monitors for enabling the two tanks to be switched periodically while maintaining a continual flow of oxygen from the system is well known. Such problems result in complexity, high frequency of repair, expense, and relative system bulk.

Disclosure of Invention

Accordingly, it is an object of the present invention to provide a novel and unique concept for providing oxygen concentration by atmospheric flow-through which does not require the necessity of switching between filtering tanks.

It is another object of the present invention to provide a novel and unique concentration concept which will

decrease the complexity and frequency of repair necessitated by prior art systems.

It is a further object of the present invention to provide a novel and unique oxygen concentration system which provides a relatively clean flow of oxygen from atmospheric air without the necessity for frequent filter changes, and in a greater degree of economy than heretofore achievable.

The foregoing objects are achieved in accordance with the present invention by providing a sequence of operations controlled by monitoring the pressurization of the oxygen ballast tank utilized for the storage of generated or concentrated oxygen. To accomplish the foregoing, a flow from the atmosphere is established by means of a port coupled to a pump which provides an airflow through a four-way valve, connected to have a first position which passes a directed flow of atmospheric air through a molecular sieve tank, and thence to an oxygen storage tank. Pressure monitoring of the pressure within the oxygen storage tank, preset at a predetermined level, causes the valve to switch at a predetermined point and thereby reverse the operation of the pump. As a result, a forced evacuation of air through the molecular sieve tank in a direction opposite to its initial flow is established. Since the pressure in the ballast tank remains sufficiently high, the flow of concentrated oxygen will continue for a short period of time in an uninterrupted manner to the ultimate user. A forced evacuation of the molecular sieve tank, since it does not rely upon the pressure within the oxygen storage tank, may be accomplished without interrupting the flow to the user and in a manner which allows the molecular sieve material to be sufficiently purged. As an additional purge, when the pressure in the oxygen tank has dropped to a further pre-determined level, a small backwash of oxygen from the oxygen storage tank through the molecular sieve can be effected as a final purge. The pressure monitoring device then detects further drops of pressure in the oxygen storage tank and returns the system to its initial format, thereby allowing the cycle to repeat. As a result, an entire purge cycle can be achieved without interrupting the flow of oxygen from the oxygen

storage tank and without requiring the use of a second molecular sieve tank. Advantages in terms of reduced size, reduced complexity, economy, simplicity and efficiency of operation are clearly evident from the foregoing arrangement.

A unique four-way valving switch as well as a unique check valve and orifice arrangement are utilizable in connection with the foregoing novel and unique concepts as also described herein.

The foregoing brief descriptions and advantages of the present invention will become more apparent from the following more detailed description and appended drawings wherein:

Brief Description of Drawings

Figure 1 is a schematic diagram of a prior art system.

Figure 2 is a schematic diagram of the preferred embodiment of the present invention.

Figures 3A and 3B are an enlarged sectional view of the flow valve or switch of Figure 2 shown in its position I.

Figure 4 is similar to Figure 3B showing the flow valve or switch in its position II.

Figure 5 is an enlarged schematic diagram of the solenoid valve and needle valve of Figure 2.

With reference to Figure 1, a typical prior art system for providing concentrated oxygen from ambient atmospheric conditions is illustrated. As shown therein, an inlet port 10 is provided, contianing a suitable filter material 12, for filtering out dust and other atmospheric impurities or the like, coupled by suitable means to a muffler 14. The muffler contains a plurality of baffles and is provided for the purpose of generally reducing noise, quieting vibration and the like. The air flow is maintained by virtue of an electrically driven pump 16, coupled to the output of the muffler 14, which channels air through a suitable hose or fitting to the molecular sieve tanks 26,36. The molecular sieve tanks, conventional devices, contain a molecular sieve material 27. The molecular sieve material 27 is generally, a material having a crystalline lattice in the form of a relatively large open structure. It is sufficiently large so that foreign molecules can fit inside

the structure and are actually captured by the structure, loosely, by adhesion. Polar molecules, such as water, water vapor, or the like, are very strongly adhered. Molecules such as nitrogen and oxygen are less strongly adhered. Nitrogen, however, is more strongly adsorbed or adhered than is oxygen. As a result, there is a continuous interchange of molecules going through the lattice structure and out again. By increasing the pressure through the molecular sieve material, additional molecules will go in. By changing the pressure, the amount of gas that is adsorbed may be varied, since the sieve material provides greater attraction of the molecular structure of nitrogen relative to oxygen. Thus, when gas is applied to the molecular sieve tank under pressure, the nitrogen component thereof will be adsorbed, leaving the oxygen content to pass through in greater concentration. When atmospheric air is passed through the molecular sieve tank or chamber under pressure, the nitrogen will tend to be adsorbed and the oxygen passed on through.

The output of the pump 16 is coupled by means of suitable couplings to a filter 18 containing a filter material for the purpose of further purifying the air passing therethrough, particularly necessary when the pump 16 is a carbon vane pump. After the oxygen passes through the filter, it is diverted through a suitable T-coupling 22.

On the other side of the T-coupling 22 are further valves 24, 28. The operation of the system is such that when one of the valves is open the other shuts, so that air is directed to the molecular sieve tank 26 in the first instance. After increasing the concentration of oxygen in the gas passing through the tank 26, the oxygen is passed through a check valve 30 into a storage tank 32, which holds the oxygen therein for delivery. The output port 34 allows for delivery of oxygen from the system. The nature of the molecular sieve tank is that after passing gas therethrough at a typical input pressure of, for example 15 PSI, or a time period typically somewhere between 15 and 25 seconds, the sieve material will no longer adsorb any further nitrogen and the nitrogen will pass through the filter, thereby

decreasing the concentration of oxygen. At this point, the valve 24 is shut and the valve 28 is opened, allowing the flow of atmospheric air through the second molecular sieve tank 36, also connected to the storage tank 32, and the operation repeats itself. While the gas is passing through the open valve 28 to the tank 36 and thence to storage tank 32, the molecular sieve tank 26 is purged by means of a suitable mechanism 40, typically utilizing part of the pressure contained within either oxygen tank 32 or the opposite sieve tank, 36. The purge is a reverse flow of gas through the molecular sieve material which dislodges the adsorbed nitrogen, thereby renewing the molecular sieve material for the next cycle. When the tank 36 has become saturated with nitrogen, the situation is reversed and the cycle begins again. This cycle of pressurization, adsorption, oxygen collection and depressurization, along with purging with oxygen, is known as a pressure swing cycle. Using this technique, a continual flow of oxygen from the storage tank 32 out the outlet port 34 is achieved.

Although effective, the foregoing prior art system has certain disadvantages, including and principally the rather complex valving and switching mechanism required, along with the inconvenience and bulk necessitated by having two molecular sieve tanks required in a single system. Since the sieve tanks must be necessarily large in order to provide even 15 or 20 seconds saturation time, the use of two systems or two tanks, along with their attendant valving and switching disadvantages with respect to both maintenance, economy and bulk. In addition, the use of the oxygen for purging further decreases the amount of oxygen available to the ultimate user, thereby undermining the very nature and objectives of this sytem.

As is typical with the prior art system, the compressor or pump 16 first performs compression, and then may assist in the purge by evacuation, along with the use of oxygen from the storage tank. The oxygen from the storage tank accomplishes two major objectives. First, it removes any residual nitrogen from the end of the oxygen storage tank, and secondly, lowers the partial pressure of the ni-

trogen in the tank so that any nitrogen remaining will tend to be pushed out. As a result, part of the oxygen supply will go to the purging of each tank, alternately, each time a purge cycle is necessary.

The present invention utilizes a novel and unique concept which results in the necessity of only a single molecular sieve tank. The advantages of only a single molecular sieve tank are clearly apparent, in terms of economy, size, bulk and complexity. Referring to Fig. 2, a system employing the concepts of the present invention, wherein only a single molecular sieve tank is utilized, is illustrated. Thus, with reference to Fig. 2, there is a port 50 capable of both inlet and exhaust functions. A suitable filter 52, for filtering out impurities, dust, dirt and the like, is located within the port 50. Suitable ducting is provided for directing the air stream from the port 50 through a muffler 54 containing baffle structures 56 for the purpose of reducing noise, vibration, and other undesirable vibration characteristics. Suitable output ducting directs the output of the muffler to a flow switch or valve 58. The flow switch 58 is a two position device having a first position I shown in solid line and a second flow position II shown in dotted line. In its first position, as shown, the air stream is then continually coupled by means of suitable ducting 60 to an electrically operated compressor or pump 62, having an air flow direction shown by the arrows 64. A secondary filter 66 may be coupled to the output of the pump 62, and contains a filter element 68 for futher air purification, particularly if pump 62 is a carbon pump. The output of the secondary filter 66 passes through the flow switch 58 to a molecular sieve tank 70, which may be of conventional construction including a molecular sieve material 72 operating as described hereinabove with respect to prior art systems. The output of the molecular sieve tank 70 is coupled through a one way or check valve 74 to an oxygen storage or ballast tank 76. The output of the oxygen ballast tank is provided via an output port 78 through a pressure regulator 80 of conventional design to

a flow adjustment mechanism 82, which includes a flow gauge 84 for measuring the through-flow. The output of the flow adjustment mechanism 82 is coupled to a further bacterial filter 86, containing a suitable bacterial filtering material 88, and thence via an output port 90, for use external to the system.

The flow switch 58 described above operates as a four-way valve and can be constructed as four two-way valves, two three-way valves, or one four-way valve for purposes of this invention. Air entering the system passes the muffler 54 and through the valving system 58 to the pump 62. Passing again through the flow switch 58 the air flow enters the molecular sieve tank 70. As is noted, only a single tank is necessary in this system. Cycling occurs by virtue of monitoring pressure in the ballast tank 76. Alternatively, cycling could be done by other means, such as time monitoring or by monitoring pressure at the oxygen end of the sieve tank. Thus, by measuring the pressure of the ballast tank, the condition of the entire system may be indicated. This is a key feature of the solution to the problem of cycling.

In position I, that is the solid line position of the flow switch 58, air flow is in the direction of arrows 64 through the inlet, muffler, pump, sieve tank 70, oxygen tank 76 and output. As a result of this air flow, pressure slowly increases in the storage tank 76. When the pressure reaches a pre-set value, by way of example, 30 PSI, the pressure switch 93 trips, the pressure switch may be activated by virtue of a pressure transducer 95 or similar conventional pressure measuring device connected to the ballast tank 76. The tripping of the pressure switch causes the flow switch 58 to switch from the position I indicated in solid lines to the position II indicated in dashed lines. The pressure switch 93 causes the flow switch 58 to trip as a result of a motor drive, or air flow through duct 93A to control port 104, located in the flow switch 58. Alternatively, switch 93 may be solenoid-activited by means of an electrical contact. In either event, activation of the

pressure switch 93 due to predetermined pressure levels in the ballast tank 76 cause the flow switch 58 to switch from the first position I to the second position II.

When flow switch 58 is in its position II, the input flow of air into the ballast tank 76 will stop. The air in the ballast tank remains under pressure since it cannot flow back through the check valve 74. Instead, the air in the molecular sieve tank 72, is vented to the inlet of the pump through the path now established by the flow switch 58 and shown by arrows A along duct 60, through the pump 62 in the air direction 64, through the secondary filter 66, through the second path position of the flow switch 58, muffler 54 and is exhausted through filter 52 and the port 50. With flow switch 58 in its position II pump 62 applies suction through ports 96 and 94 of valve 58 to the inlet side 70A of sieve tank 70 which then draws air from the tank 70 backwards through the molecular sieve 72, thence through ports 94 and 96 to and through the pump 62 and finally through ports 92 and 98 through filter 52 and out through exhaust 50, thereby drawing down the tank 70 and evacuating same to a partial vacuum condition.

Meanwhile, as flow to the user continues out of the ballast tank 76, the pressure therein slowly drops. When pressure in tank 76 drops to 20 PSI, for example, purge solenoid valve 97 is activated to open allowing a flow of oxygen from tank 76, in an amount controlled by a predetermined orifice such as needle valve 97A, through port 70B of the sieve tank 70, and through the sieve material 72 as a final oxygen purge. The purge solenoid 97 and valve 97A will be described in further detail in later paragraphs.

This new arrangement and system gives rise to several advantages. First, the purging action required for restoring the molecular sieve filter material 72 to its initial condition is effected by means of the evacuation caused by virtue of the pump 62. Secondly, reversal of the air flow through the port 50 causes the filter 52, which may have had accumulated dirt, dust, etc. formed along its inlet side to be exhausted by means of the reverse flow effect.

Thus, lint and dirt are blown off the inlet filter and back out the exhaust port. As a result, the filter is cleaned each cycle, automatically, and it is no longer necessary to change filters as often as in prior systems. In fact, it is now only necessary to inspect the filter occasionally a year because of various oils or greases or impurities that cannot be simply purged by air flow. Thus, the life of the filter is significantly increased.

In regard to the oxygen purge phase of the molecular sieve tank 70, it should be noted that the solenoid and needle valve system is not essential, it is only required that some means of limiting back flow of oxygen from the ballast tank 76 through the molecular sieve tank at a lower pressure be established. Thus, for example, a small drilled orifice, allowing a small leak of oxygen back through the molecular sieve tank at a certain minimal pressure may be sufficient. Thus, in comparison with prior art system, wherein the air flow in the opposite tank was employed for purging from the pressurized side through to the evacuated side, the present invention actually uses the air pump and the ballast in the ballast tank 76 for purging purposes. The second sieve tank is therefore no longer required, thereby giving rise to the principal advantage of the present invention. Furthermore, the ballast tank 76 is structured sufficiently large to handle the flow to a patient and to handle the flow to purge the sieve tank 70. Thus, when the pressure in the ballast tank reaches its secondary level, i.e., 20 PSI, the small amount of oxygen vented back to the sieve tank 70 to purge the remainder of the nitrogen is pumped out by virtue of the action of the evacuation caused by pump 62 through the flow switch 58 to its second position. Thus, the present invention employs an evacuation concept, not simply air pressure flow, for purging purposes. When the ballast tank reaches its next lower level somewhat below 20 PSI, but above atmospheric pressure, the pressure switch 93 again causes the flow switch 58 to return to its initial position and the cycle begins again.

Several safety devices can be added to insure the

correct operation of the pressurization cycle. Thus, for example, should the pressurization cycle take more than a predetermined time period an alarm 91 is provided which will sound and the pump will be directly shut off. As long as the flow adjustment in any tube is set so that the flow rate does not exceed the pumping capacity of the pump 62, the recycling time of the molecular sieve tank, and ultimately the storage capacity of the ballast tank, the flow of oxygen out of the system along the line 90 will be maintained at a relatively constant level. Components, unless otherwise indicated, are standard components, such as flow meters, pressure regulators, the various filters, mufflers, ports and tanks.

Referring to Figures 3 and 4, a mechanical detail of afour-way flow switch, uniquely adapted for purposes of this invention is indicated. As shown in the figure, the flow switch 58 consists of a body 90 having a plurality of inlet and outlet ports, 92, 94, 96 and 98. The central communicating bore 100 is traversed by means of a piston 102 having two positions, position I shown in Figure 3 and indicated by solid lines in Figure 2, and position II shown in Figure 4 and indicated by dotted lines in Figure 2. A further orifice or port 104 shown in Figures 2, 3 and 4 communicates duct 93A with oxygen tank 76 via air flow valve 99 which is activated by pressure switch 93, as previously described. The activation of the valve 99 causes a vacuum pressure or air pressure to be introduced to the part 104 for the purposes of moving the piston from its solid line position I to its dotted line position II. As will be evident, in position I port 92 is connected through to port 94, and port 96 is connected through to port 98. In position II port 92 is connected through to port 98, and port 94 is connected through to port 96, corresponding to the second position of flow switch 58 indicated in dotted lines. In position I air enters through port 98, exits out to the pump through port 96 and into the valve through port 92 and out to the molecular sieve tank through port 92. In position II air comes out of the tank through ports 94 and 96 to the pump, and is exhausted through ports 92 and 98, the two inputs 92 and 92A

of the three port side being communicating together, via a common inlet 92B. These two ports could also be provided to separate exhaust inlets for reducing the exhaust back pressure.

The piston 102 could be solenoid operated, air operated, or motor driven. In the preferred operation, the piston 102 is driven into position by means of a motor drive 93 as shown in Figure 3A. The motor drive 93 includes a threaded drive 95 which in turn cooperates with an internally threaded opening 97 in the center of the piston 102. Upon actuation, the motor drive 93 can force the piston into the initial position as shown in the drawing by virtue of the action of the motor drive 93. An alternative embodiment for positioning the piston 102 is shown in Figure 3B. For purposes of economy and portability a third spool 102A is provided on the piston 102 with the additional chamber 102B (Figure 4) cooperating therewith to create in essence, a smaller air drive chamber. Now, by venting air from tank 76, duct 93A to port 104, which is at high pressure during the pressurizing cycle, a finite length of time is required for the pressure to drop even after the switch is activated. Thus, by venting the chamber ending in port 104, for example 2 seconds at the end of each cycle, with high pressure, pressure will be therefore available to push the piston 102 over to the position II of the flow switch resulting in evacuation purge position. The flow switch 58 closes several seconds later so that pressure is trapped in the housing chamber 102A, and the flow switch is thereby kept in the same position II. At this point, the system is operating through the oxygen purge cycle. When purge is complete and evacuation has created a partial vacuum, the pressure switch 93 again is reactivated, hence opens the chamber 104 to allow partial vacuum to pull the spool end 102A back to the initial position I. As also shown in the Figures 3 and 4 a spring 120 is provided in the end cap 122 for providing a further positive force urging the piston into into position I at normal atmospheric pressure, so that no matter when the machine is turned off, whether pressurizing or de-pressurizing, the spool valve will always start out in the position I, or the pressurizing cycle.

To control this apparatus during the oxygen pressure cycle and the gas purging and oxygen purging cycles there is a system of valves shown in Figure 2 between molecular sieve tank 70 and oxygen ballast tank 76; however, these valves may be combined in part into a single control device 107 illustrated in Figure 5, which bears reference numerals corresponding to similar functional elements in Figure 2. More particularly, during the oxygen pressure cycle oxygen flows from port 70B of the molecular sieve tank to inlet 107A of the control device, thence through check valve 74, then to outlet port 107B to the oxygen ballast tank 76.

The initial gas purge cycle begins when the pressure switch 93 senses 30 PSI, for example, in tank 76 and activates flow switch 58 as described earlier. The final step is the oxygen purge which occurs when the pressure switch senses 20 PSI, for example, in oxygen tank 76 and activates solenoid valve 97 which allows a flow of oxygen from tank 76 through needle valve 97A at a flow-limiting orifice provided in substitution for the needle valve, through port 107A and into molecular sieve tank 70 to flow backward through the molecular filter material. Thus, a brief shot of oxygen is directed through the sieve material at the end of the gas purge cycle which is essentially an evacuation flow drawn by pump 62.

An additional value 150 may be provided in communication with the check valve 74 chamber, which may be coupled directly to the flow switch 58 for activation thereof. More specifically, the output of the additional valve 150 may be coupled to the vacuum port 104 of the flow switch 58.

Other forms of valves may be employed in conjunction with the present invention. Thus, the four-way valve may be in any form suitable for effecting the passage communication function described above. The needle valve structure in valve unit 107 for providing a final back flow of oxygen can be provided in various additional forms, such as in component form, rather than integral.

In addition, although only a singular molecular sieve tank is described it is understood that additional

tanks, hooked serially or in tandem can be employed to increase system capacity, while still operating within the framework of the present invention. The multiple sieve tanks thus described would operate in accordance with the unilateral backwash technique described.

Further variations, modifications, alterations, additions and deletions will be apparent to those skilled in the art.

Claims

1. In an oxygen concentrator, the combination comprising, a bidirectional flow system connected through a flow switch, said flow switch coupled to a molecular sieve tank to establish a primary flow, an oxygen ballast tank having an inlet, an outlet, and a pressure switch to said tank,

said pressure switch responsive to a build up of pressure thereby reversing the flow through said molecular sieve tank in a direction opposite to said primary flow, thereby purging said molecular sieve tank, said pressure switch further responsive to a drop in said ballast tank pressure for restoring said flow swtich and re-establishing said primary flow.

2. The combination of claim 1 wherein said bidirectional flow system includes a pump, said pump providing said primary flow and said opposite flow, said opposite flow purging said molecular sieve tank by evacuation.

3. The combination of claim 1 wherein said pressure switch is responsive to a further pressure level between said build up and drop for permitting a portion of said ballast tank contents to purge said molecular sieve tank.

4. The combination of claim 1 wherein said concentrator further includes valve means operative in response to the actuation of the reverse flow for directing a portion of the contents of said ballast tank to flow through said sieve tank in said opposite direction.

5. In an oxygen concentrator, the combination comprising an oxygen ballast tank for storing and releasing stored oxygen, monitoring means for monitoring the pressure within said tank, a sieve tank containing a molecular adsorption material, means for directing a flow of atmospheric gas through said sieve tank for removing nitrogen, means for directing oxygen from said sieve tank to said storage tank, said monitoring means responsive to a predetermined build up in pressure in said storage tank, cutting off flow to said ballast tank and reversing said flow in said sieve tank for a predetermined period of time for purging said tank.

6. The combination of claim 5 including a pump,

said pump providing said flow for pressurizing and purging said molecular sieve tank by evacuation.

7. The combination of claim 5 wherein said monitoring means is responsive to a further pressure level between said build up and drop for permitting a portion of said ballast tank contents to purge said molecular sieve tank.

8. A method of concentrating oxygen from atmospheric gases in a flow controllable ballast tank comprising the steps of:

forcibly directing a flow of atmospheric gases through a molecular sieve tank for concentrating oxygen in the effluent therefrom,

directing said effluent into said ballast tank,

monitoring the pressure of said ballast tank,

reversing the pressurizing flow through said sieve tank when the pressure of said ballast tank reaches a high predetermined point for purging said tank to thereby evacuate said sieve tank and interrupting the flow of gas into said ballast tank, and

restoring the original flow condition when said pressure drops to a low predetermined point.

9. The method of claim 8 wherein said method includes the further step of passing a small quantity of oxygen from said ballast tank through said sieve tank in said reverse flow mode as a final purge when said pressure is at a point between said high and low points.

10. The method of claim 8 wherein said method includes the further step of passing a quantiy of oxygen from said ballast tank through said sieve tank during said reverse flow mode.

FIG. 1

PRIOR ART

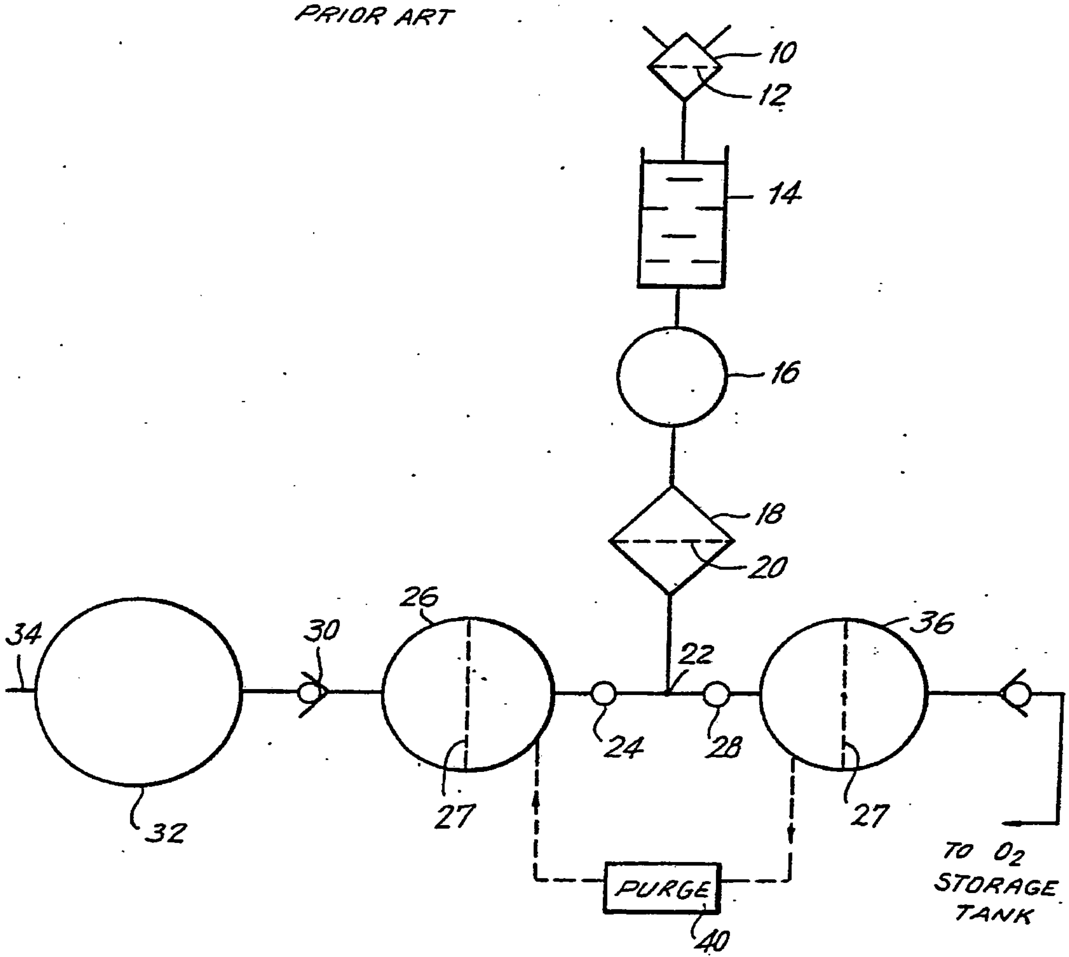

FIG. 2

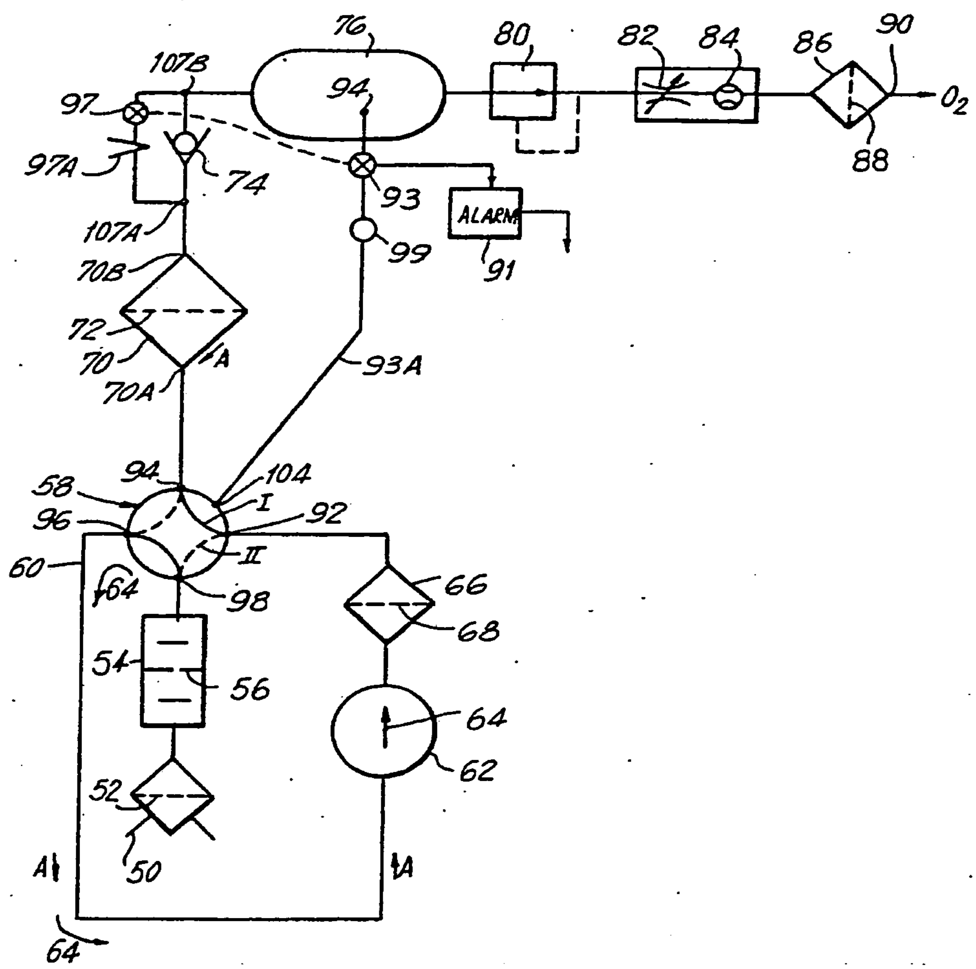

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FIG.3A

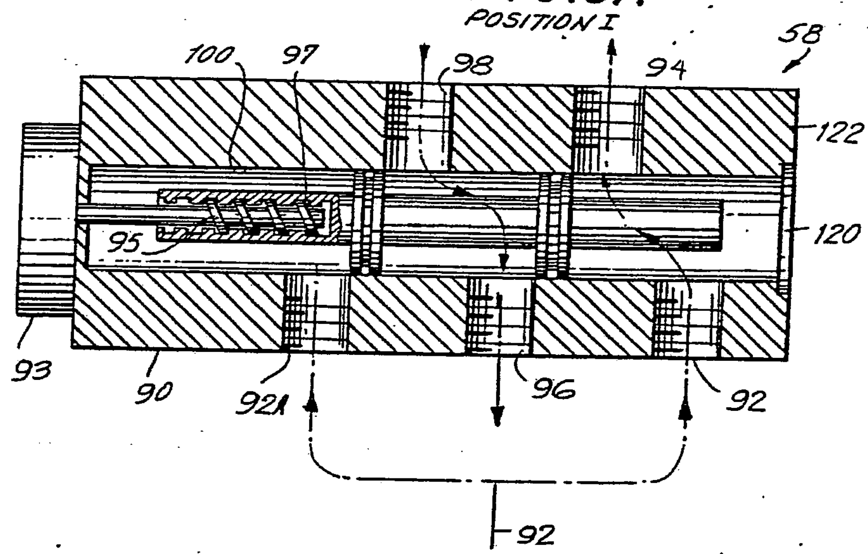

FIG.5

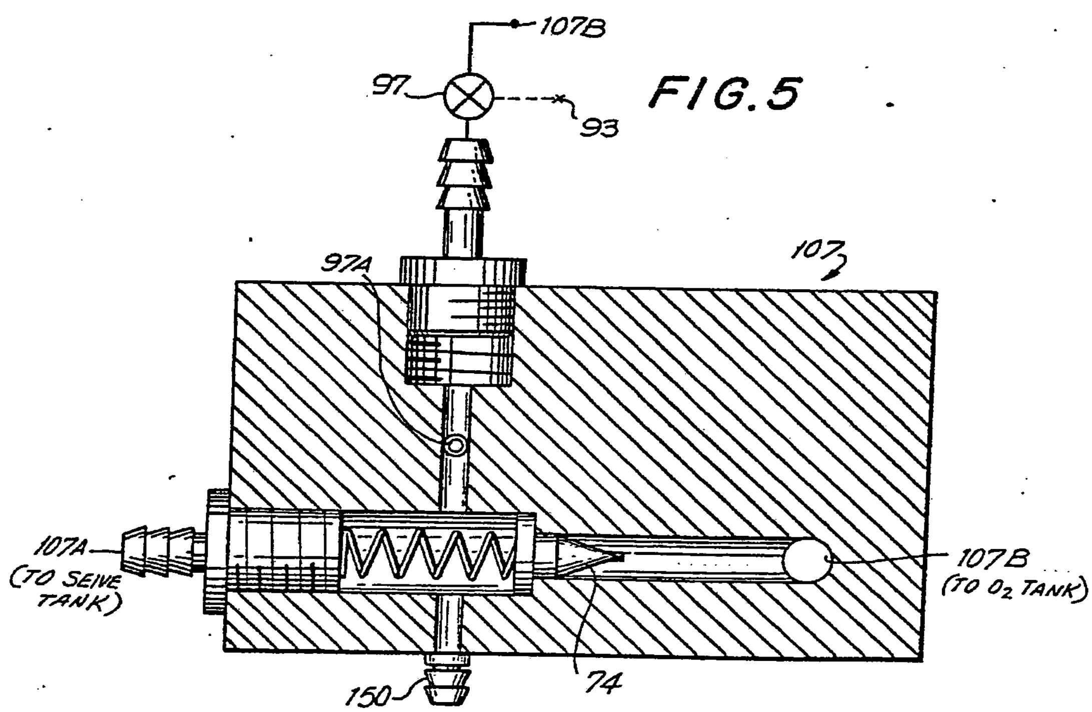

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FIG. 3B

POSITION I

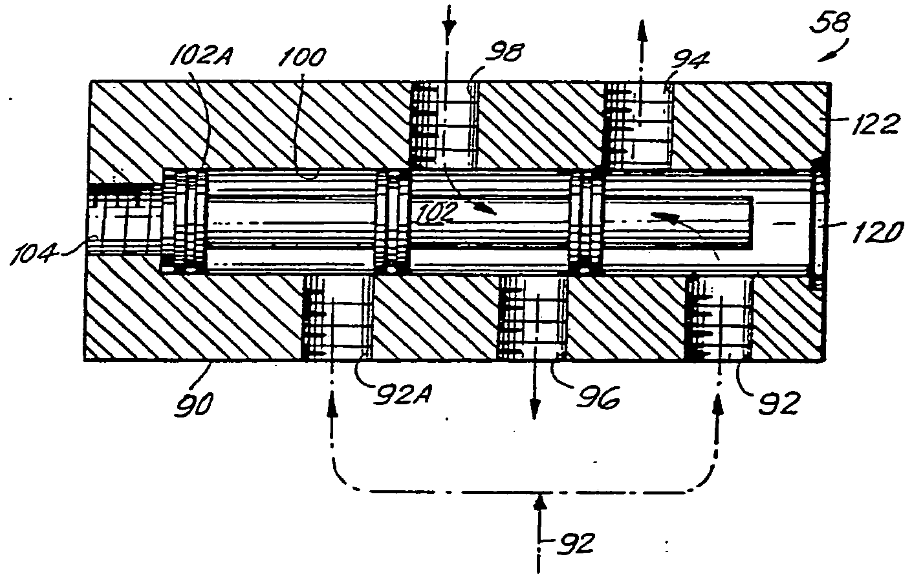
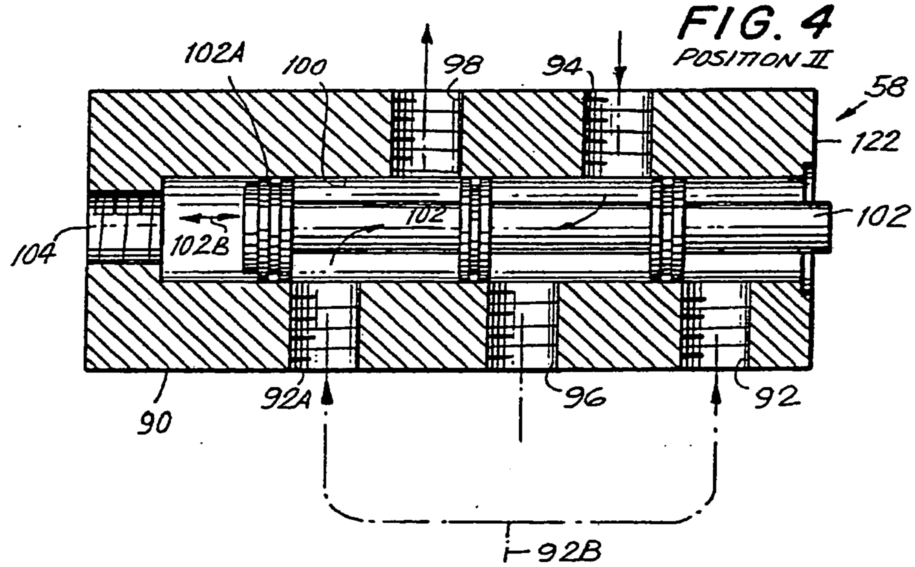


FIG. 4

POSITION II



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INTERNATIONAL SEARCH REPORT

International Application No PCT/US83/00703

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL.3 B01D 53/04
US CL. 55/75

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	55/18,21,25-26,58,62,68,75,161-163,389

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

NONE

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	US, A, 3,182,435, PUBLISHED 11 MAY 1965, AXT..	5,7-10
Y	US, A, 2,955,673, PUBLISHED 11 OCTOBER 1960, KENNEDY ET AL.	1-4,6
A	US, A, 3,147,095, PUBLISHED 01 SEPTEMBER 1964, KANUCH.	1-10
A	US, A, 3,160,486, PUBLISHED 08 DECEMBER 1964., BUSCH, JR.	1-10
A	US, A, 3,395,511, PUBLISHED 06 AUGUST 1968, AKERMAN.	1-10
A	US, A, 3,399,510, PUBLISHED 03 SEPTEMBER 1968, KAUER, JR. ET AL.	1-10
A	US, A, 3,464,186, PUBLISHED 02 SEPTEMBER 1969, HANKISON ET AL.	1-10
A	US, A, 3,659,399, PUBLISHED 02 MAY 1972, KAUER, JR. ET AL.	1-10
A	US, A, 3,778,967, PUBLISHED 18 DECEMBER 1973, KAUER, JR. ET AL.	1-10

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
18 JULY 1983	27 JUL 1983
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	Robert H. Spitzer ROBERT H. SPITZER

International Application No. PCT/US83/00703

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	US, A, 3,922,149, PUBLISHED 25 NOVEMBER 1975, RUDER ET AL.	1-10
A	US, A, 4,065,272, PUBLISHED 27 DECEMBER 1977, ARMOND.	1-10

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ______, because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ______, because they relate to parts of the International application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.